INSPECTION, TESTING & CONSULTANCY LTD

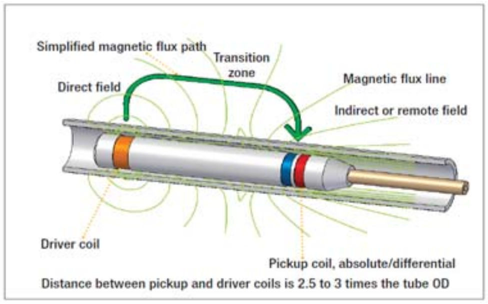
Tube Inspection Datasheet

The process of advanced tubing inspection is to supplement major turnaround inspections in the petrochemical industry via a number of NDT methods. The methods include Remote Field Eddy Current, (RFT) Magnetic Flux Leakage (MFL), Internal Rotary Inspection System (IRIS) and Eddy Current (ET).

Cost savings include lower inspection costs, lower turnaround costs, avoiding lost production, and allow better planning of inspection and maintenance intervals. To achieve these savings and improve integrity, the owner-user must understand the capabilities and pitfalls of the NDT technologies in order to select, apply and interpret the results of these methods.

The petrochemical industry depends on many heat exchangers and boilers for efficient operation. As these components consist of many tubes tightly held together, they are very hard to inspect visually or with normal ultrasonic or radiographic thickness measuring techniques. Inspections used to take two to three weeks to assess the condition of a boiler or heat exchanger. New NDT technology has developed portable equipment that combines simple operation, reliable flaw detection, and easy reporting. In the past, tests were limited to visual inspection and destructive testing (splitting) of small-bore tubing in heat exchangers and boilers. Based on total number of tubes inspected at that time, engineering decisions normally led to either a risky approach involving possible unscheduled shutdowns or a too conservative approach where tubes were plugged or replaced too early at a high cost to the petrochemical industry. As a result the local petrochemical industry now adopts and uses
field portable inspection systems to thoroughly inspect small-bore tubing.

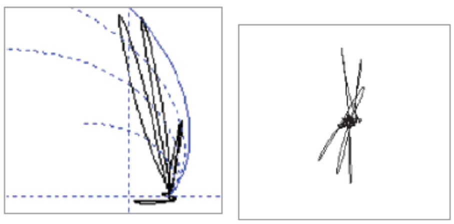
They all operate on one hardware and software platform. These systems allow for fast screening (around 400 tubes per day) with one technique with the ability to simply change a probe head and validate accurately defective areas with a more accurate method. In this manner high risk or over conservatism in replacement decisions can be avoided.



Remote Field Eddy Current Technique

Remote Field Eddy Current Technique

Remote Field Eddy Current Inspection is an electromagnetic technique that is well adapted to the inspection of small-bore ferromagnetic tubes such as carbon steel. In industry, it is now the method of choice for boilers and heat exchangers tube examination because of its low frequency (typically 50-1000Hz). The basic RFT probe consists of two coils in a send-receive configuration.



The exciter coil, energized with a low frequency alternating current, sends a signal to the detector coil spaced around two and half tube diameters away. The field emitted by the exciter coil passes through the tube wall to the outside of the tube, propagates axially, and then transits back through the wall to arrive at the detector coil. Where the tube grows thin, there is effectively less shielding. Hence the field arrives with less time delay (greater phase) and less attenuation (greater amplitude). Phase and amplitude traces are generated as the probe is pulled through the tube and are used to detect and size metal loss.

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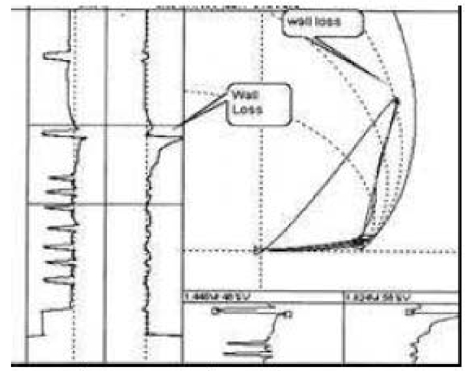
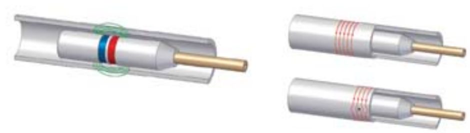
RFT uses a low frequency signal which allows electromagnetic energy to penetrate the tube walls so that external and internal flaws can be detected with approximately the same sensitivity. Flaw sizing with RFT is done using the Voltage-Plane curves These curves are used to size tube wall loss but not pits. The curves relate flaw depth, flaw length, and the flaw circumference to the phase of the remote field signal. Inaccuracies result because the geometry of the actual flaw is not defined as in the calibration defects.



Voltage plane Curves

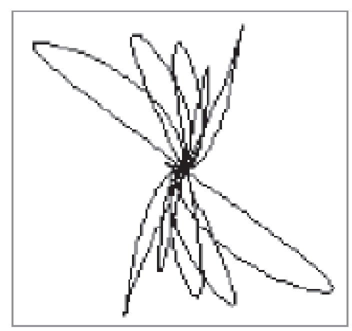
Eddy Current Technique

Eddy Current technique is an electromagnetic technique that is adapted to the inspection of small-bore nonferromagnetic heat exchanger tubes such as stainless steel, titanium, copper, brass, copper-nickel alloys, inconel, etc. Eddy Current is based on the principles of electromagnetic induction. This process includes a test coil through which a varying or alternating current is passed. A varying current flowing in a test coil produces a varying electromagnetic field about the coil. This field is known as the primary field. When an electrically conductive test object is placed in the primary field, an electrical current will be induced in the test object. This current is known as the eddy current. Eddy current flow in the test material produces a secondary electromagnetic field in the material that opposes the primary electromagnetic field. The magnitude of the secondary electromagnet field is directly proportional to the magnitude of the eddy current.



Eddy Current Technique

When eddy current varies, secondary electromagnetic field also varies. Hence the impedance of the coil changes as the electromagnetic field interacts with the material. Characteristic changes in test object such as conductivity, permeability and geometry will cause eddy current to change. Variations of eddy current are reflected to the test coil by changes in the primary electromagnetic field. Eddy Current Field inside small-bore tube Typical eddy current instrument contains 4 frequencies in both differential and absolute modes. The differential mode detects pits and cracks and the absolute mode detects gradual wall loss.

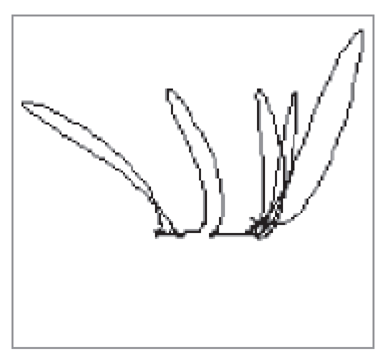


Differential response

The multi frequency testing is done for two reasons:

1. To differentiate between defects and metallic deposits. This is essential because metallic deposits can produce eddy current signals that resemble defect signals. Improper resolution of signals will result in unnecessary plugging of tubes.

2. To detect defects under the support plates. This is done by using a two-frequency mix to cancel the support plate signal and detect defects under the support plate



Absolute response

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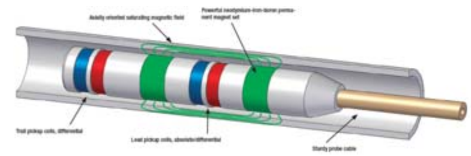
Flux Leakage Technique

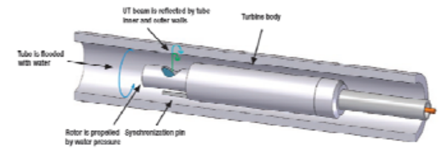
Magnetic Flux Leakage Technique is an electromagnetic technique] that is adapted to the inspection of small-bore ferromagnetic heat exchanger tubes such as carbon steel. The MFL probe consists of a magnet with two types of magnetic pickups: coil type and Hall element. The coil type sensor picks up the rate of change of flux while the Hall type picks up absolute flux. The coil detects small defects that cause perturbations in the flux . The rate of change of flux induces an output voltage (Faraday's Law) which is read by the MFL instrument. The Hall element sensor is used to detect gradual wall loss. The output of the MFL coils is related to change of flux caused by the defect, but not the defect size. Hall Element measures the absolute flux and can be used for sizing wall loss type flaws (not pits).



Flux Leakage Technique

Ultrasonic Iris Technique

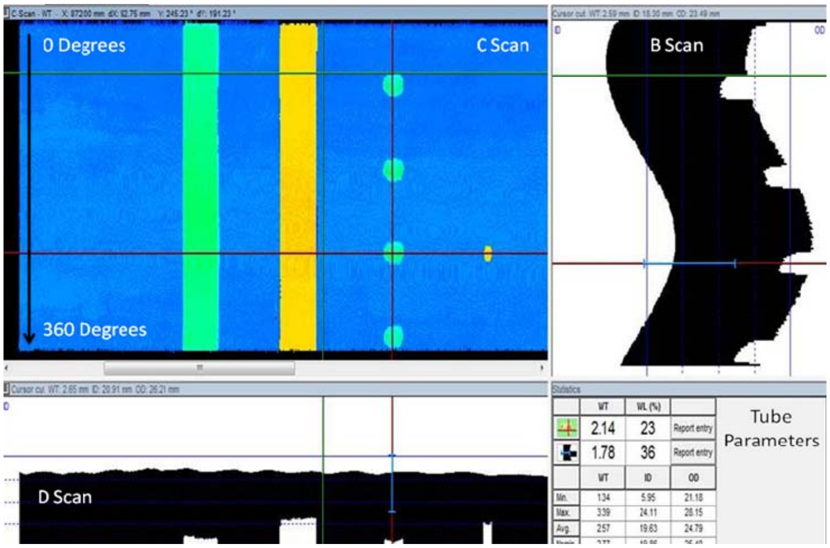
Ultrasonic Internal Rotary Inspection System (IRIS) is based on the principle of measuring thickness using ultrasonic waves. The IRIS probe consists of an ultrasonic transducer that is lined up in the centerline of the tube and incident on a rotating mirror. The mirror reflects the beam in the radial direction as it rotates in the tube. The IRIS probe scans the entire circumference of the tube as it is pulled out of the tube.



Ultrasonic Iris Technique

The IRIS method is mostly used for inspection of carbon steel tubes and is sometimes used in non-ferromagnetic tubes for defect verification. The method is very accurate for thickness measurement as well as detecting ID and OD pits. IRIS will, however, miss pinholes and cracks.

The IRIS display includes the cross-section of the tube (B Scan and D Scan) as well as a C-scan of the tube Tube Length



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